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Any communication on the subject of this letter should be addressed to—

THE SECRETARY,
MINISTRY OF HOME SECURITY
(A.R.P. DEPT.),
HOME OFFICE,
WHITEHALL,
LONDON, S.W.1.

and the following number quoted—
H.S.C. 290/1940.
O./GEN./244/8.

MINISTRY OF HOME SECURITY,
AIR RAID PRECAUTIONS DEPT.,
HOME OFFICE,
WHITEHALL,
LONDON, S.W.1.

11th December, 1940.

Home Security Circular No. 290/1940.

Air Raid Shelters.

SIR,

I am directed by the Minister of Home Security to request you to bring urgently to the notice of your engineering staff the notes on shelter design which are set out below. These notes contain modifications which in the light of actual experience it has been found to be desirable to introduce in the standard designs of surface, trench and basement shelters, together with observations as to certain measures which it is considered should be undertaken as regards existing shelters of these types.

It is intended in the immediate future to issue a Memorandum framed in the light of recent experience on the best form of shelter within the rooms of existing houses.

I am, Sir,

Your obedient Servant,

G. H. GATER.

Issued to all local authorities in England, Wales and Scotland.

The Clerk of the County Council.
The County Clerk.
The Town Clerk.
The Clerk of the District Council.

NOTES.

BRICK AND CONCRETE SURFACE SHELTERS.

(i) *New design.*

A new design (Drawing No. ARPD/CE/158), has been introduced which embodies certain important changes, viz. :—

(*a*) the use of reinforced brickwork in place of ordinary brickwork ;

(*b*) the introduction of a bituminous damp proof course ;

(*c*) the introduction of the principle of oversailing the roof.

The object of (*a*) and (*b*) is to increase the resistance offered by these structures to earth shock, (*b*) will also help, as will (*c*), to mitigate dampness. Alternatively to (*a*), the walls may be carried up in ferro-concrete of the standard and thickness required by the Revised Code, the vertical reinforcement being tied to the roof in a manner similar to that shown in the drawing.

All future communal shelters should embody the principles shown in the design. This involves, in their case, the abandonment of the various alternative roof designs introduced early in 1940 (Memorandum No. 14), in order to overcome the acute shortage of steel for reinforcement. The earlier designs may continue to be used for individual shelters but for their construction reinforced brickwork should be used and the reinforcement carried into the covering roof concrete. A bituminous damp proof course should also be included.

(ii) *Measures in connection with existing shelters.*

(*a*) Defective mortar : remedial measures.
(*b*) Brick arch roofs.
(*c*) Damp.

(a) *Defective Mortar.*

(i) Experience has shown that during the period when the use of lime-cement mortar was encouraged in order to save cement, unsatisfactory lime or bad lime-cement mixes have in some cases been used with the results that the mortar has not set or hardened even after relatively long periods ; and in other cases, possibly through insufficient wetting of bricks before laying, although the mortar is satisfactory there is little or no adhesion between mortar and brickwork. It is imperative that all surface shelters constructed to any mortar specification containing lime should be immediately examined for these defects and where they are found to exist in a mild degree the joints on the both faces should be deeply scraped and grouted with cement mortar.

In bad cases where the mortar is still weak after a prolonged period the walls should be rebuilt in reinforced brickwork with cement mortar

(b) *Brick arch roofs.*

Some local authorities, because of local conditions with regard to materials have resorted to a roof consisting of two 4½-inch brick rings in the form of a semi-circular arch. Where this has been done the outer ring should be backed at the springings with concrete in fine aggregate in the manner shown in Drawing No. ARPD/CE/159. All such arches should be turned in cement mortar. If this mortar has not been used in any existing structure then the mortar should be immediately examined and if any doubt exists as to its strength then the outer ring should be rebuilt in cement mortar and the shewback concrete extended right over the barrel to give at least 3-inch thickness at the crown.

(c) *Damp.*

The suggestions made in this section have special application to areas where shelters are used regularly for sleeping.

Damp can be attributed to several specific causes although a great deal of the apparent dampness is due to the same causes as exist in a newly built or rarely occupied house. The following remedies may be applied :—

(i) *Damp walls due to roof drainage.*

Drawing No. ARPD/CE/160 shows two methods of coping with this difficulty.

The method showing the continuous layer of bituminous felt serves the double purpose of providing a drip course and waterproofing a badly constructed roof which allows infiltration either because of the employment of faulty mixes or because no camber has been given to the roof.

(ii) *Damp from infiltration through roofs and walls.*

Specifications have been drawn up of mixtures, etc., suitable for surface application where infiltration is evident. These are to be found in the Appendix to these Notes.

(iii) *Entry of water over the floor of the shelter.*

Shelters have in some cases been so sited or the floor constructed to such levels that water can back into the shelter from the entrance. This should be immediately remedied by alterations to the floor and where necessary the provision of a slightly raised threshold across the entrance. In many cases it has been necessary to construct shelters with one wall at pavement level and the parallel wall on the carriage way leaving the gutters uncovered in the shelters. Where such shelters are being used for dormitory purposes this must be remedied. A suitable method would be the provision of a pipe or box gutter, the floor being brought to level by rubble filling and covered with a 3-inch concrete or tarmacadam floor. Alternatively, a covering floor may be constructed from salvaged timber when available.

(iv) *Rain driving in through unprotected entrances.*

This usually applies to surface shelters which have no roof connection between the baffle wall and the shelter. The entry of driving rain may lead to conditions of some discomfort and when such conditions do arise from this cause a light canopy should be constructed over the entrances. Such canopies can also be so constructed as to provide a means for light obscuration.

B.

TRENCH SHELTERS.

(a) *Design.*

Experience has shown that while all approved types of linings have stood up to the bomb effects against which they were originally designed, some types of precast linings have shown themselves relatively vulnerable to earth shock from a near-by explosion. The types in question are those which use precast linings with vertical side members fitting into recesses in horizontal top members.

Accordingly in future designs of this type should not be used unless strengthened as indicated below. As between other types, having regard both to strength and to damp prevention, designs using "in situ" ferro-concrete should be preferred. Typical designs are shown in Drawings Nos. ARPD/CE/161 and 162. These designs are for 4 foot 8 inch and 7-foot linings; the latter being more suitable for dormitory purposes as it takes two lines of bunks.

(b) *Strengthening of existing trenches having vertical side members fitting into recesses in roof members.*

In view of the relatively high vulnerability of linings of this type to earth shock which may first cause a lift of the roof, then collapse of the sides and finally of the roof, all trenches in which such linings are used should be strengthened in one of the following ways:—

(i) *Illustrated on Drawing ARPD/CE/163.*

The method consists of complete frames at 6-foot intervals with longitudinal angle members running the length of the trenches at the two top corners.

(ii) *Illustrated on Drawing ARPD/CE/164.*

The drawing shows details of baffle walls within the trench, of reinforced brickwork tied in to a new reinforced concrete floor and roof over the length of the baffle. This reinforced concrete roof replaces the precast roof members over that distance. The baffles should be not more than 20 feet apart and can be spaced to fit in with any projected scheme of bunking. Channel

irons supported by the baffle walls will prevent the side units of the trench from collapsing inwards and the roof members from falling down. The channel irons should be given additional lateral strength by bolting wooden struts between the two sides. The channels should be designed to withstand a vertical load equal to the weight of roof and earth above and a lateral load equal to 1.5 times the vertical load.

(c) *Damp.*

Although in general the trouble from infiltration from subsoil water has been anticipated and countered, a certain amount of discomfort is being experienced by persons using trenches for dormitory purposes as a result of leakage through the roofs of trenches lined with precast members. In such cases the earth covering the trenches should be removed and the roof should be treated with a waterproof layer of suitable asphaltic or bitumastic material. When the earth is replaced it should be properly consolidated in thin layers and extra earth added to form a camber to carry off surface water. It may be found more convenient and economical in some cases to camber the earth above the shelter and lay a tarmac surface thereon. In sites liable to heavy water logging where blocks of trenches have been constructed it may be necessary to lay the tarmac surface over the whole area of the block, care being taken to provide ample slopes for drainage purposes.

C.

BASEMENTS.

Experience of bombing has pointed to certain measures as of importance :—

(a) *Subdivision.*

Many shelters are being used by greater numbers than intended. The consequence is that individual compartments are accommodating more persons than is admissible. By now such cases must be known and action should be taken to ensure that the numbers using such shelters are reduced or that adequate subdivision into compartments is undertaken. Experience has shown that dividing walls need not be taken to the height of the ceiling but may stop at a height of 6 feet or so. The work if possible should be carried out in reinforced concrete or if brickwork is used, it should be reinforced in the way shown in Drawing ARPD/CE/158 for new surface shelters.

(b) *Pavement Lights.*

Experience has shown the danger of penetration through pavement lights. Although it was never contemplated that any shelter should resist the effect of a bomb striking as close as this, the calamity risk can be very much reduced by cutting off the

pavement light or similar area by a heavy vertical wall and in any large basement shelter used to capacity for dormitory purposes this should be done immediately. The thickness of the wall must be of the order of 2 feet 6 inches or 3 feet whether in brickwork or concrete with the outside flush with the building line or better still at a distance inside the building line. Alternatively a lighter wall can be used and the area filled with rubble.

This applies with equal force to shelters in framed buildings.

(c) *Strutting.*

There is evidence that in some cases the basement strutting has been affected laterally by the earth movement from a bomb exploding under the surface near to the shelter boundary. This has not usually occurred when the strutting and strengthening beams have been comprised of structural steel with the usual steel framing gussets and fastenings ; nevertheless, in such cases it would appear that too much reliance for lateral stability has been placed upon a tight fitting between the strengthening beams and existing members of the floor above, and on bearing walls.

The use of the ordinary tubular struts, originally designed for domestic basements has been approved for the strutting of larger public shelters ; but, in some cases, too little attention has been paid to the bracing of these struts when so used. The point cannot be over emphasised in the light of recent experience that when such struts have been used and there are more than four of them in any line, adequate bracing must be effected. It is also desirable to fix the base plates to the floor either with say bolts or by encasing the bases in concrete footings. *All such shelters should be immediately examined with this in view.*

Again, recent experience has shown that where, owing to shortage of steel in the past, brick piers have been used, the resistance of a shelter against the effects of a near miss can be vastly improved by reinforcing the brick piers with a light steel stanchion either side of the pier and framed into the supporting beams. In order further to increase the resistance of the shelter it would be advisable in any future construction to avoid the use of brick piers, but if used they should be built in cement mortar and reinforced with vertical bars.

(d) *Emergency Exits.*

Finally, in a number of cases it has been found that persons in basement shelters have been trapped through the blocking of the emergency exit. It is of the first importance that, wherever practicable, additional emergency exits should be provided communicating with adjoining basements. Even if these exits are not kept normally open, they can greatly facilitate the operations of rescue parties.

APPENDIX.

Waterproofing Treatments for Exposed Surfaces of Brick and Concrete Surface Shelters.

The following preparations are suggested because they will give a reasonable degree of waterproofness quickly and because of the simplicity of application. They can all be applied by brush.

1. *Bituminous paints.*

These should only be applied to concrete and brick surfaces reasonably dry. The paints can be briefly specified as :—

> " Asphaltic bitumen or coal-tar pitch, or mixtures thereof, dissolved in a suitable non-aqueous volatile solvent and of painting consistency. Pigments or fillers may also be present. The product when applied as a film of normal paint thickness should be dry to the touch in not more than two hours under normal conditions."

2. *Bituminous emulsions.*

These can be applied to a wet surface but not generally to a waterlogged one, but should not be applied when rain is expected within a few hours after application. They can be made quicker drying by stirring about 5 lbs. of Portland Cement in 2 gallons of water and adding the whole to about 10 gallons of emulsion. These can be briefly specified as :—

> " A liquid product in which a substantial amount of asphaltic bitumen or tar, or a mixture thereof, is suspended in a finely divided condition in an aqueous medium and stabilised by means of suitable materials with or without fillers. The product should be sufficiently stable for brush application."

3. *Black varnish* briefly specified as :—

> " A black varnish consisting of coal-tar pitch fluxed with creosote oil and a proportion of crude solvent naphtha."

These are as a rule slow drying and can only be applied to dry surfaces and liable to be damaged if rain falls within the drying period of about 12 hours.

4. *Coal tars* for cold application.

These can be applied to a wet surface but not a waterlogged one and can be briefly specified as :—

> " Coal tar of sufficiently fluidity for cold application and preferably dehydrated by refining."

5. *Coal-tar pitch mixes* for hot application.

Should be applied only to a moderately dry surface and can be applied alone or above a primary coat of dehydrated coal tar applied cold. A brief specification would be :—

> " Coal-tar pitch mixture suitable for hot application and of such a character as to give a tough flexible coating."

General.

The treatment No. 4 (Coal tar for cold application) will be the cheapest. This, or the bituminous emulsion plus cement (2) will be the most suitable

for application to damp concrete. In any case, however, there must be no water standing on the surface, and the concrete should have had a few hours drying subsequent to the removal of any standing water.

If conditions are such as to permit the use of hot coal-tar pitch mixes (5) this form of treatment will give the most watertight surface. Provided the conditions permit of satisfactory application the watertightness of the surface will probably decrease in the order (5), (2), (1), (3) and (4).

While the relative durability to weather of these treatments is somewhat doubtful, it can be improved by surface finishes such as sanding before the surface has dried. In all cases, further dressings can be applied later as required.

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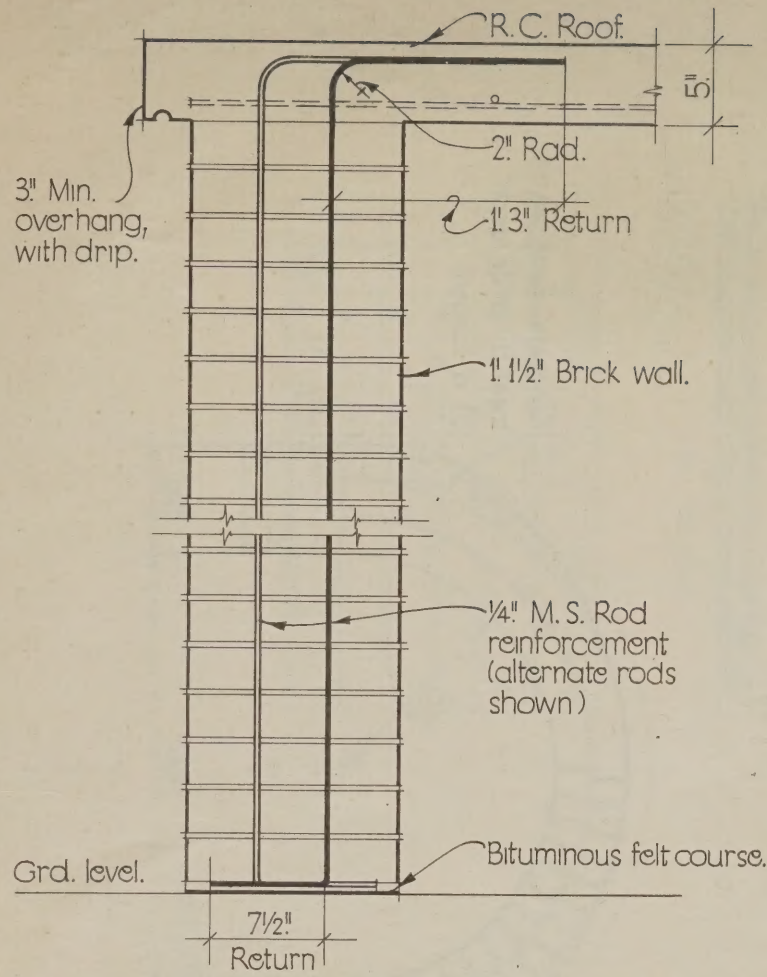
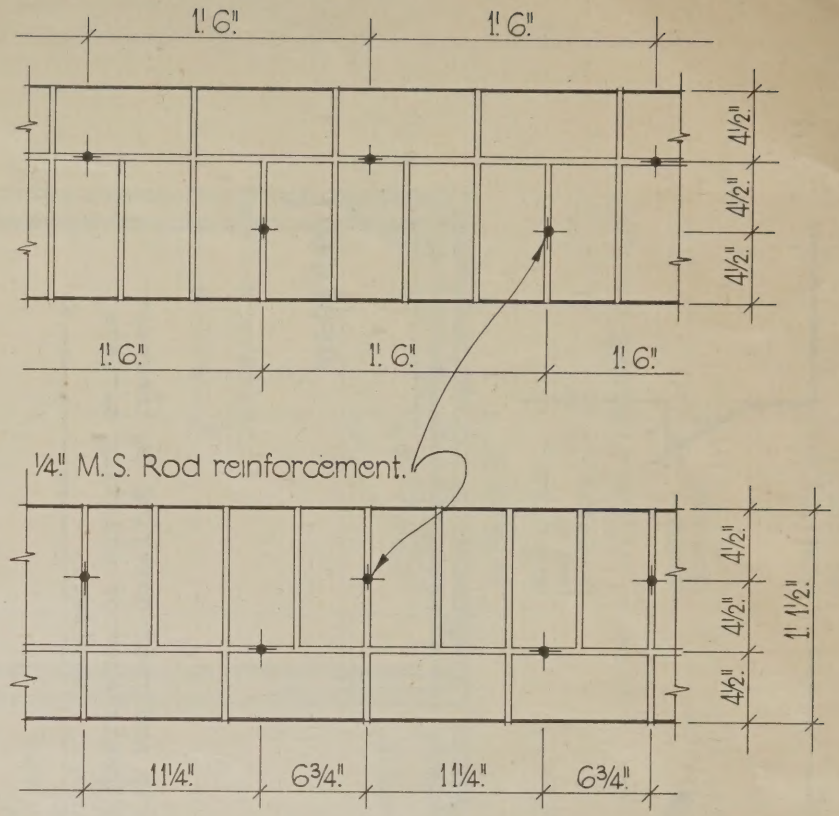


SECTION.

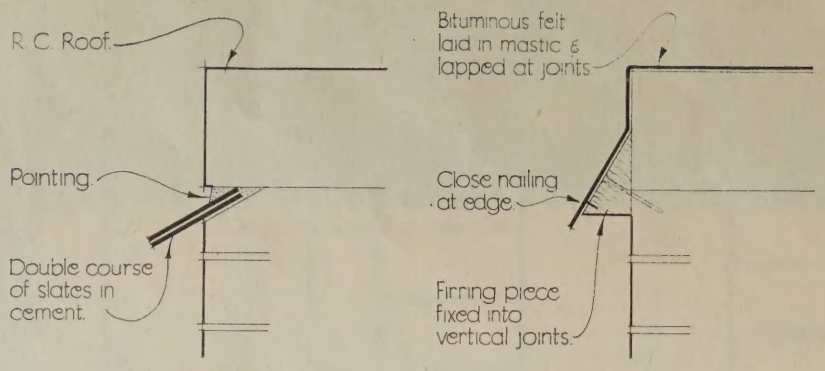


PLANS OF ALTERNATE BRICK COURSES.

Scale: 12. 6. 0. 1. 2. Ft.

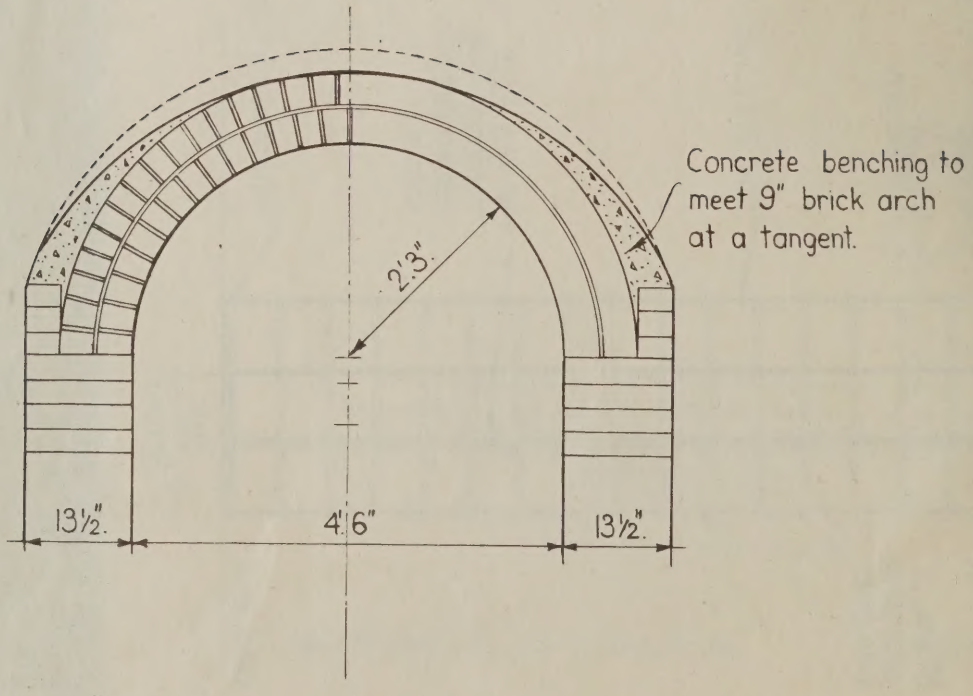
Details of reinforced brick walls for surface shelters.

ARPD/CE/158.



A.R.P.D./CE/160.

Detail of drip and roof covering to increase the weather resistance of existing surface shelters.

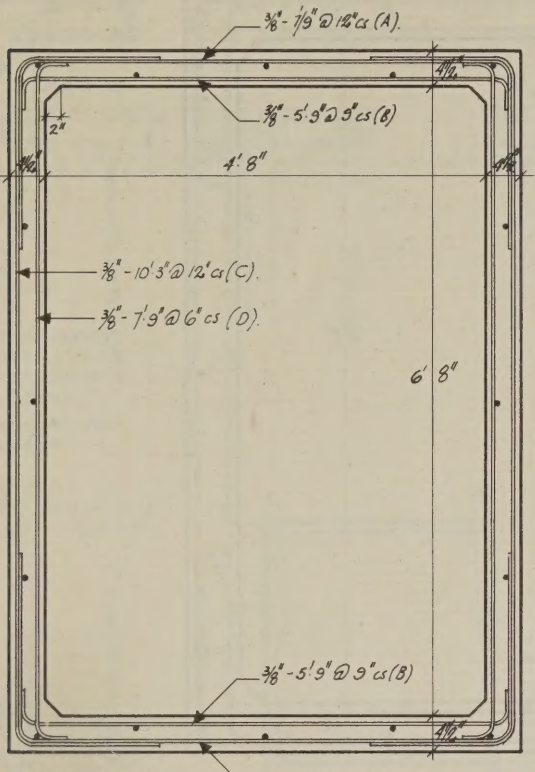


A.R.P.D./C.E/159.

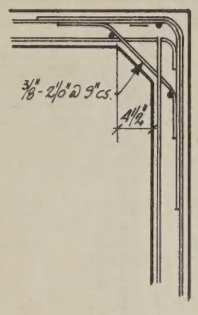
Detail of brick ring arch roof for surface shelter.

APPROXIMATE QUANTITIES OF MATERIALS IN ONE YARD RUN OF TRENCH OF TYPICAL SECTION

CONCRETE : 1 cub. yard
STEEL : 1·05 cwt.



TYPICAL SECTION



ALTERNATIVE DETAIL AT WALL AND ROOF & WALL AND FLOOR JUNCTIONS

Adds 18 lbs reinforcement per yard run

SCHEDULE OF REINFORCEMENT

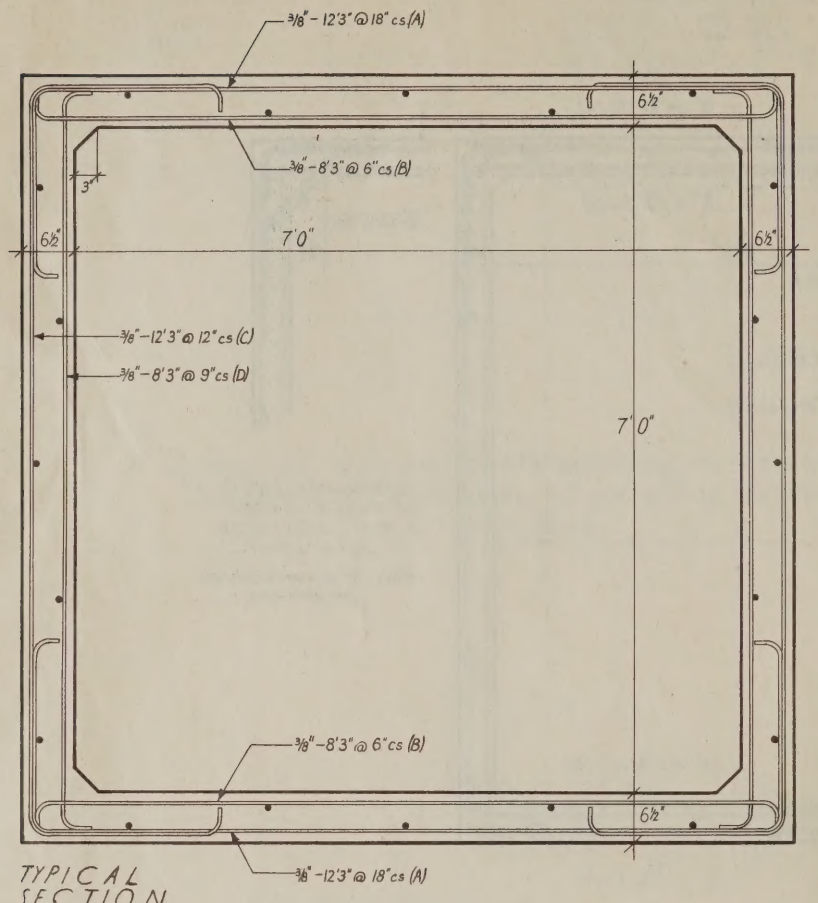
Bar.	Position	Diam	Spacing	Total length	N° per yd run	Dimensions to centre line of bars
A.	Floor & Roof	3/8"	12"	9'3"	6	2½" 5'3" 2½"
B.		3/8"	9"	5'9"	8	3" 5'3" 3"
C.	Walls	3/8"	12"	10'3"	6	1½" 7'3" 1½"
D		3/8"	6"	7'9"	12	3" 7'3" 3"
	Longi-tudinal bars	3/8"	As shown	Any con-venient lengths	16	Straight

ARPD/CE/161.

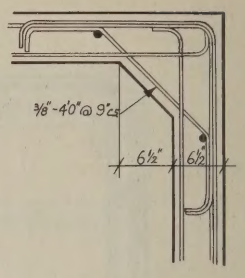
Details of in-situ reinforced concrete trench lining 4'8" wide.

APPROXIMATE QUANTITIES OF MATERIALS IN ONE YARD RUN OF TRENCH OF TYPICAL SECTION

CONCRETE : 1·8. cu.b. yard.
STEEL : 1·2. cwt.



TYPICAL SECTION



ALTERNATIVE DETAIL AT WALL AND ROOF & WALL AND FLOOR JUNCTIONS.

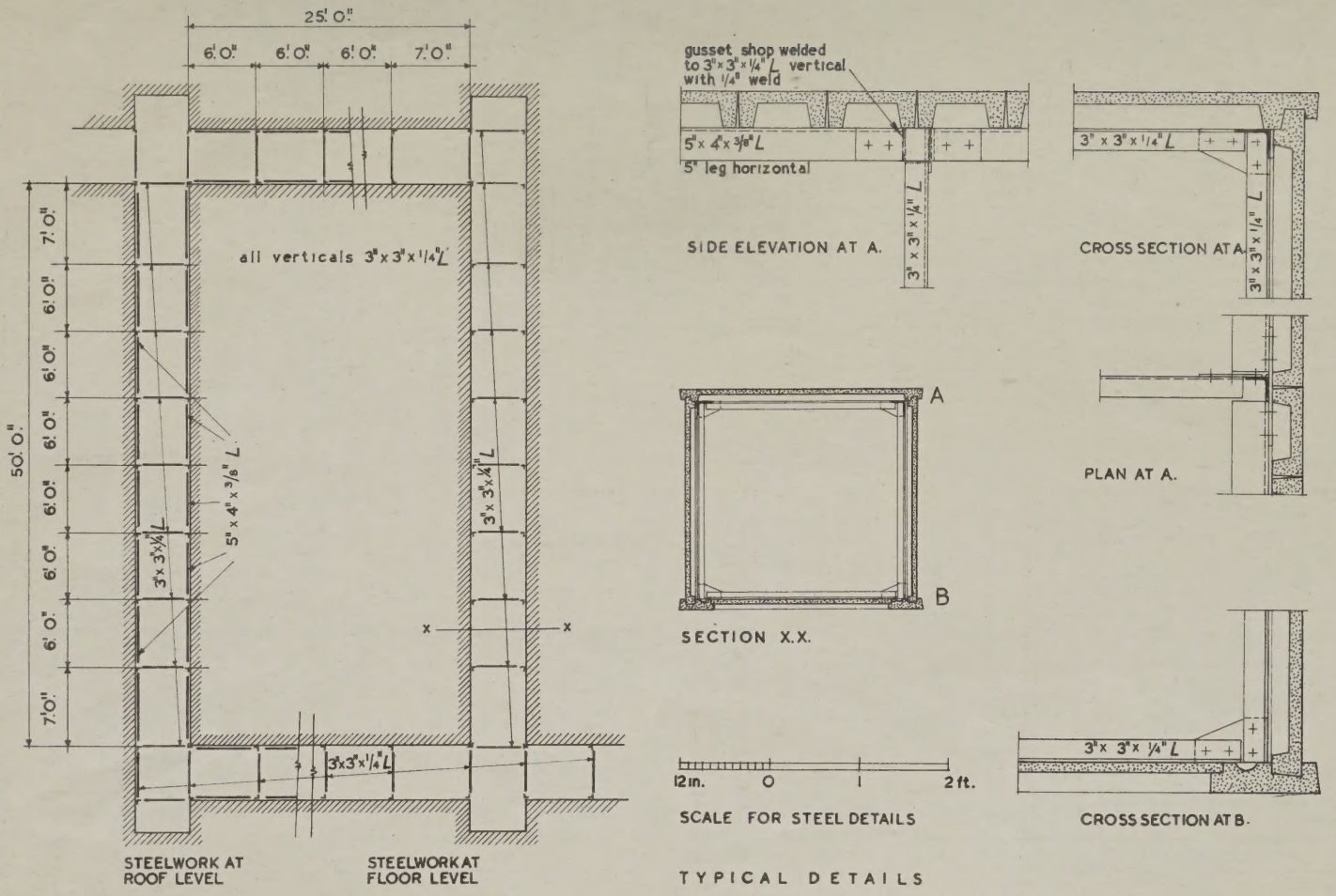
Adds 24 lbs reinforcement per yard run.

SCHEDULE OF REINFORCEMENT

Bar.	Position	Diam.	Spacing	Total length	No. per yd run	Dimensions to centre line of bars
A.	Floor & Roof	3/8"	18"	12'3"	4	2'0" 3" 7'9" 3" 2'0"
B.		3/8"	6"	8'3"	12	3" 7'9" 3"
C.	Walls	3/8"	12"	12'3"	6	2'0" 3" 7'9" 3" 2'0"
D		3/8"	9"	8'3"	8	3" 7'9" 3"
	Longi-tudinal bars	3/8"	As shown	Any con-venient lengths	20	straight

ARPD/CE/162

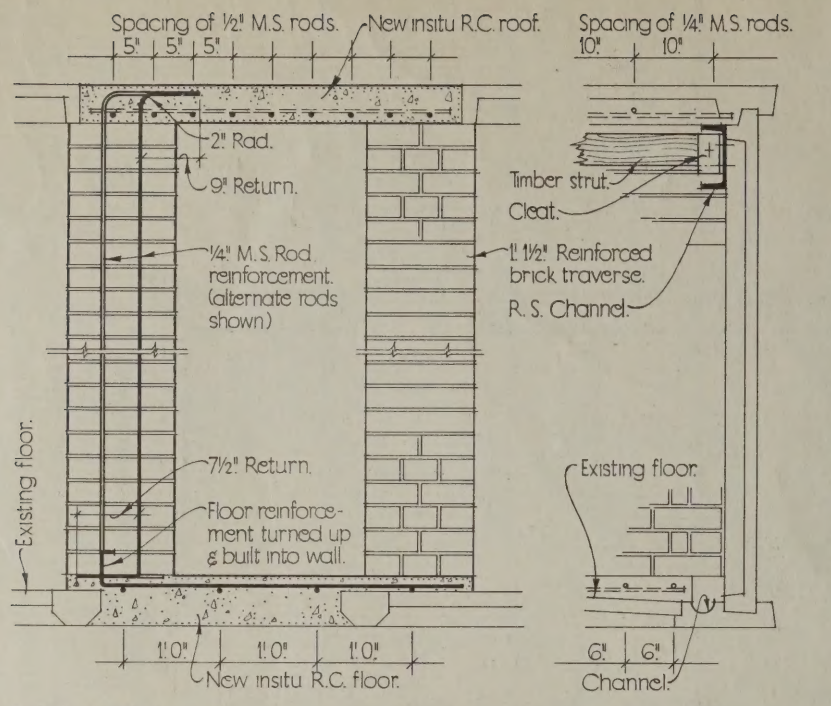
Details of in-situ reinforced concrete trench lining 7'0" wide.



TYPICAL DETAILS

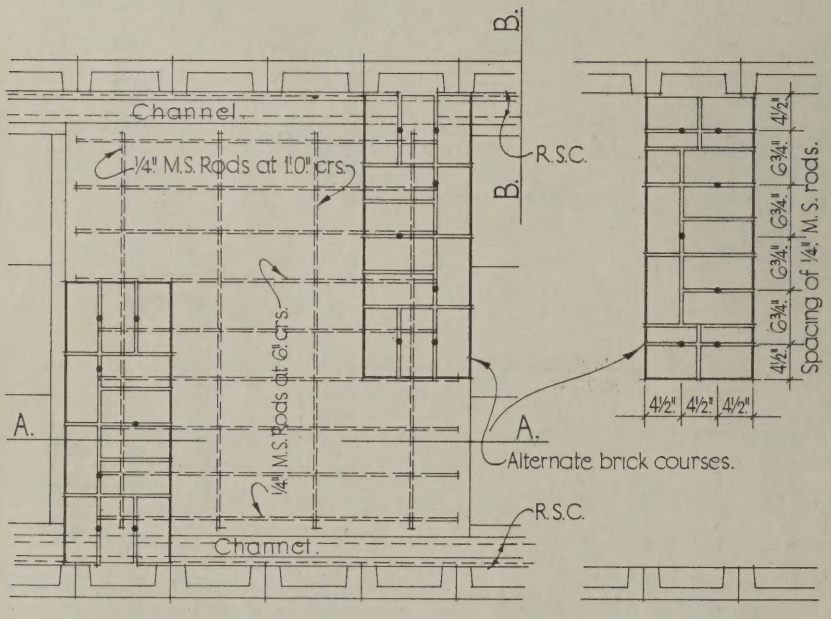
ARPD/CE/163.

General arrangement and details of steel strengthening for standard trench layout.

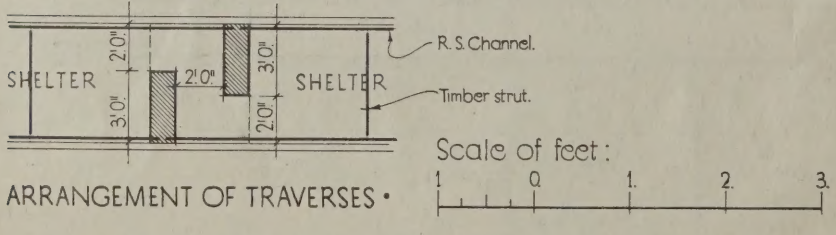


SECTION A.-A.

SECTION B.-B.



PLAN.



ARRANGEMENT OF TRAVERSES.

ARPD/CE/164.

Details of reinforced brick traverses for existing precast reinforced concrete unit shelters.